

X-ray emitting AGN unveiled by the Chandra Multiwavelength Project

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Abstract.

We present an X-ray and optical analysis of a flux limited ($f_{2.0-8.0\text{keV}} > 10^{-14} \text{ erg s}^{-1} \text{ cm}^{-2}$) sample of 126 AGN detected in 16 Chandra fields. This work represents a small though significant subset of the Chandra Multiwavelength Project (ChAMP). We have chosen this limiting flux to have a reasonable degree of completeness (50%) in our optical spectroscopic identifications. The optical counterparts of these hard AGN are characterized as either broad emission line AGN (BLAGN; 67%), narrow emission line galaxies (NELG; 22%) or absorption line galaxies (ALG; 11%) without any evidence of an AGN signature. Based on their X-ray luminosity and spectral properties, we show that NELG and ALG are primarily the hosts of obscured AGN with an intrinsic absorbing column in the range of $10^{21.5} < N_{\text{H}} < 10^{23.3} \text{ cm}^{-2}$. While most of the BLAGN are unobscured, there are a few with substantial absorption. X-ray surveys such as the ChAMP nicely complement optical surveys such as the SDSS to completely determine the demographics of the AGN population.

1. Introduction

X-ray surveys of the extragalactic universe in the era of Chandra and XMM-Newton are for the first time able to probe the demographics of the AGN population irrespective of any moderate obscuration. Current deep surveys such as the CDF-N (Brandt et al. 2002) and the CDF-S (Tozzi et al. 2001) are unveiling AGN with an abundant amount of gas hiding the bright quasars and the lower luminosity Seyfert galaxies. This obscuration can be large enough to effectively hide any optical signature of an active nucleus and prevent the inclusion of these sources in optical surveys such as the SDSS. With the unprecedented sensitivity and resolving power of these current observatories, we are able to probe large volumes in an unbiased fashion to determine the prevalence of X-ray emitting AGN and their subsequent evolution.

How do these obscured sources fit into the AGN unification scheme? Many of these do not necessarily have optical AGN signatures. Is this a result of

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host dilution (Moran, Filippenko, & Chornock 2002) or some other geometry/structure that prevents us from viewing the narrow line emitting gas? While optical extinction and X-ray absorption normally go hand in hand (Turner et al. 1997), there are a number of cases to the contrary (i.e. Akylas, Georgantopoulos, & Barcons 2003; Panessa & Bassani 2002).

While the deep fields do cover a large volume, shallower and wide field surveys are needed to compile a significant sample of sources with 2-8 keV flux levels around $10^{-14} - 10^{-15} \text{ erg s}^{-1} \text{ cm}^{-2}$ which comprise most of the 2-8 keV CXRB (Cowie et al. 2002). With large samples of all AGN types, we can determine the relative importance and nature of these new AGN to the parent population.

2. The Chandra Multiwavelength Project (ChaMP)

The ChaMP provides a medium-depth, wide-area sample of serendipitous X-ray sources from archival Chandra fields covering $\sim 14 \text{ deg}^2$. The broadband sensitivity between 0.3–8.0 keV enables the selection to be far less affected by absorption than previous optical, UV, or soft X-ray surveys. Chandra’s small point spread function ($\sim 1''$ resolution on-axis) and low background allow sources to be detected to fainter flux levels. The project effectively bridges the gap between flux limits achieved with the Chandra deep field observations and those of past ROSAT and ASCA surveys.

We present preliminary results from the ChaMP using a bright subsample (126 identified AGNs; $f_{2.0-8.0\text{keV}} > 10^{-14} \text{ erg s}^{-1} \text{ cm}^{-2}$) of 437 hard X-ray sources detected in 16 ChaMP fields. This flux limit includes a significant fraction of sources with spectroscopic identifications. To construct a pure AGN sample, we require the observed 2.0-8.0 keV luminosity to exceed $10^{42} \text{ erg s}^{-1}$. Our motivation is to determine the demographics of the hard X-ray emitting AGN, measure the range of intrinsic obscuration, and determine the extent to which obscuration of X-rays translates to extinction in the optical.

2.1. X-ray observations

We have chosen 16 Chandra fields for which we have acquired followup optical imaging and spectroscopy. A full description of the ChaMP image reduction and analysis pipeline XPIPE can be found in Kim et al. (2003). For the following analysis, we require a $S/N > 2$ in the 2.5-8.0 keV band to generate a hard X-ray AGN catalog which minimizes any inherent systematics due to absorption of soft X-rays. We restrict the off-axis angle of the Chandra detections to less than $12'$ since the sensitivity is significantly reduced.

2.2. Optical followup

We have acquired optical imaging for each Chandra field to identify counterparts to X-ray sources. We have utilized the NOAO 4m telescopes with the MOSAIC camera to cover the full Chandra field of view. The complete details of the ChaMP optical followup program including strategy, image reduction, and source detection can be found in Green et al. (2004).

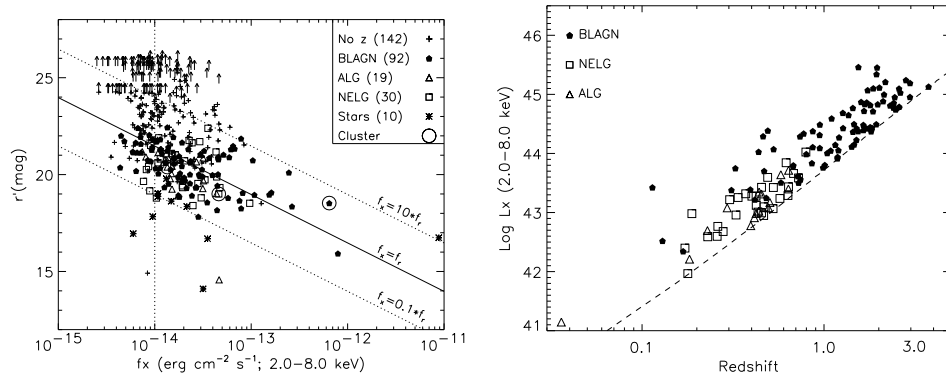


Figure 1. *left* X-ray flux (2-8 keV) vs. optical magnitude (r'). *right* Luminosity (erg s^{-1})/redshift distribution of ChaMP AGN.

Optical spectroscopy is crucial for determining the source type and redshift. The majority of optical spectra are acquired from the CTIO/4m and WIYN/3.5m with HYDRA, a multi-fiber spectrograph. To extend the identifications beyond $r' \sim 21$, we are observing on Magellan and the MMT to reach $r' \sim 22.5$. Objects with strong emission lines ($W_\lambda > 5\text{\AA}$) are classified as either Broad Line AGN (BLAGN; $\text{FWHM} > 1000 \text{ km s}^{-1}$) or Narrow Emission Line AGN (NELG). For counterparts with weak emission line or purely absorption line, spectra are classified as Absorption Line Galaxies (ALG). Any stellar source is labelled as STAR. If the associated X-ray emission is extended the object is further labelled as a cluster member.

3. ChaMP AGN: X-ray and optical properties

We show the optical magnitude as a function of X-ray flux for all sources (378) detected in 14 of the 16 fields which have reliable optical photometry (Fig. 1). We find that 67% of the identified AGN are classified as BLAGN. Many of the Chandra sources (NELG-22%, ALG-11%) do not resemble the typical AGN found in optical surveys. Their spectrum is characteristic of the host galaxy and not primarily associated with the AGN itself.

Since 85% of all Chandra sources in these medium depth fields are AGN, hard X-ray surveys have a high degree of efficiency for finding accreting, super-massive black holes. It is evident that Chandra is capable of detecting hard AGN out to $z \sim 4$ (Fig. 1). Based on the strong X-ray luminosity of the NELG and ALG, we would expect to detect optical emission from the AGN which suggests the presence of severe extinction.

The NELG and ALG are only seen for $z < 0.8$. The steep drop in their numbers for $z > 0.8$ is primarily due to a selection bias. A luminous galaxy ($10L_\star$) at $z \sim 0.8$ is fainter than our limit for optical spectroscopic followup ($r' = 22$).

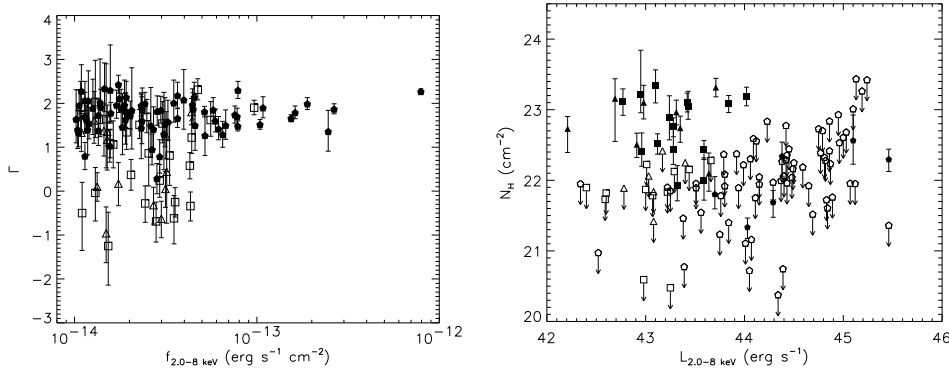


Figure 2. *left* X-ray photon index (Γ) as a function of X-ray flux. *right* Intrinsic N_H vs. luminosity. Filled symbols (*right*) mark the constrained measurements and open symbols are upper limits.

4. X-ray spectral fitting and intrinsic absorption

We find that there is a direct relationship between the X-ray and optical properties of these hard AGN. We fit the X-ray count distribution for each source with a powerlaw with the spectral index (Γ ; Fig 2 left.) and N_H set to the galactic value. Errors are 90% confidence intervals. The BLAGN have $\Gamma \sim 1.9$ which is expected for unabsorbed AGN. Most NELG and ALG have a flatter spectral slope ($\Gamma < 1.5$). The AGN that lack broad optical emission lines, probably due to dust extinction, suffer from significant X-ray absorption as well.

We re-ran our fitting routine, assuming all sources can be fit with a powerlaw, fixed $\Gamma = 1.9$, galactic N_H and an additional intrinsic absorber. We find that the NELG and ALG have intrinsic absorbing columns with $10^{21.5} < N_H < 10^{23.3} \text{ cm}^{-2}$ (Fig. 2 right). While most BLAGN are consistent with no intrinsic absorption, there exist a few BLAGN which are absorbed. As evident, we need a larger sample to accurately measure their contribution to the 2-8 keV CXRB.

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